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Tatiana Fic

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DIW Berlin

German Institute
for Economic Research

Königin-Luise-Str. 5
14195 Berlin,
Germany

Phone +49-30-897 89-0
Fax +49-30-897 89-200

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IDENTIFYING DETERMINANTS OF GERMAN INFLATION

AN ECLECTIC APPROACH

Tatiana Fic*

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Abstract

The paper applies an equilibrium correction model to discuss impacts of monetary, labour and external factors on the German inflation. The approach presented is of eclectic character and allows for examination which variables representative for various inflation theories matter empirically when analysing inflation processes in Germany. The results obtained suggest that inflation in Germany is determined by adjustment processes on the market of production factors, external shocks embodied in import prices, level of capacity utilisation and monetary policy actions.

Key words: equilibrium correction model, inflation modelling, Germany

JEL class.: C2, C5, E3

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Address for correspondence: Tatiana Fic, Department of Macroeconomic and Structural Analysis, National Bank of Poland, ul. Swietokrzyska 11/21, 00-919 Warsaw, Poland, e-mail: Tatiana.Fic@mail.nbp.pl

1. INTRODUCTION

There are numerous studies analysing inflation behaviour and trying to identify its determinants. They are based on various theories embodied in models such as P star models (see e.g. Gerlach and Svensson, 2000, Herwartz and Reimers, 2001), models of the price-wages feedback (see e.g. Marcellino and Mizon, 2000, Welfe and Majsterek, 2001) or mark-up models (see e.g. Dewan, Hussein and Morling, 1999). Inspirations for empirical models usually come from single inflation theories describing a part of the economy and a few economic forces which are considered to drive inflation movements. Applying a particular theory automatically implies that the starting set of inflation determinants is pre-specified and restricted to variables coming from the chosen theory only. Thus, the space for empirical investigation is limited – and, as inflationary processes are more complex than described by an inflation theory, it cannot be excluded that estimated models are misspecified.

The approach presented in this paper treats inflation as a phenomenon having many different sources that not always can be attributed to one particular theory. Inflationary pressures appear in different sectors of the economy, on different markets, and inflation behaviour resulting from complex economic constellations is difficult to model. The paper presents an eclectic model that uses various theoretical concepts to explain inflation movements, and the applied methodology is based on multicointegration. The objective of the article is to test which variables representative for sundry inflation theories matter empirically when analysing inflation processes in Germany. Eclectic approaches to inflation modelling were also employed by Hendry (2001) and Buyng-Yeon Kim (2001), and suggested by Juselius (1999).

The organisation of the paper is the following. Section 2 describes the structure of an equilibrium correction model. Potential inflation sources and their theoretical backgrounds are discussed in section 3. Section 4 addresses inflation processes in Germany and section 5 interprets empirical results. Last section concludes.

2. THE MODEL

The starting point for the analysis of inflation processes in Germany is an equilibrium correction model. The idea of the model is to explain inflation movements as being driven by excessive demand or supply in different sectors of the economy, that is, resulting from disequilibria on different markets (see Hendry, 2001). Defining equilibrium in terms of a cointegrating relation, a measure of disequilibrium can be derived as a deviation of the price level from its theoretical equilibrium value. As the inflation is determined by a plethora of

factors and their mutual connections, at the early stage of estimation, the inflation equation should encompass as many cointegrating relations as many potential disequilibria sources there are. During the estimation process insignificant variables are successively deleted, allowing for identification of inflation determinants. The model is eclectic which implies there are no *a priori* restrictions about the variables' set which would be the case, was a particular theory the starting point for the empirical model.

The modelling strategy consists of two stages and is similar to the two step Engle-Granger methodology. At the first stage, particular cointegrating relationships are estimated separately as single equations. Then, the error correction terms obtained, are inserted into the inflation equation. Thus, the general formula for the equilibrium correction model can be written:

$$\Delta p_t = c + \sum_i ect_{it} + \sum_i x_{jt} + \zeta_t, \qquad (1)$$

where

Δp - inflation (difference of the log of the price level),

ect_i - error correction terms - deviations from the equilibrium on a market i (residuals from the cointegration relation),

x_j - other (stationary) exogenous variables (the variables' set will be defined in next sections – it encompasses differences of nonstationary variables entering cointegrating relations as well as other stationary variables).

Terms called ect_i correspond to equilibrium relations. For a variables' vector $\mathbf{z}$ an equilibrium relationship holds if the component $\xi = \mathbf{az}$ by which actual observations deviate from the equilibrium is a mean-zero stationary process. That is, the discrepancy between the outcome and the postulated equilibrium has a fixed distribution, centred on zero, that does not change over time (see Banerjee *et al*., 1993).

Including more than one cointegrating relation (with each relation analysed separately) into one equation constitutes the main difference when compared to the commonly used error correction model. It does not, however, obstruct the analysed processes since it could be interpreted as one equation from an implicit non-linear VAR (see Hendry, 2001).

The model is estimated using the *general-to-specific* methodology. Identification of significant inflation determinants enables testing which factors (and also which price theories) apply to the German data.

3. INFLATION SOURCES

In an open economy there are three main sources of inflation: monetary inflation, wage inflation and imported inflation (see Buyng-Yeon Kim, 2001). The monetary inflation appears in situation, when the money supply does not correspond to the growth of the domestic product, which implies that the money supply is not equal to the money demand. The wage inflation results from wages increases boasting excessive demand and leading to higher unit costs, which directly lead to higher inflation. The imported inflation goes through the medium of exchange rates and foreign prices. Import prices could provide an alternative framework for an analysis of the domestic prices increases in regard to external shocks.

Monetary inflation

Following monetary concepts, the real money is a function of the gross domestic product and an interest rate. Price increases result from imbalances between the money supply and the money demand. Analytically the relationship could be written as[1]:

$$m - p = L(y, r) \tag{2}$$

where:

m - nominal money

p - price level

y - real GDP

r - interest rate

The above equilibrium condition is a static concept which implies changes of the price level may be analysed using comparative static analysis that is deriving a hypothetical effect of a change in one variable under *ceteris paribus* assumption. This assumption is very strong and should be relaxed, as susceptibility of all variables to shocks may permanently change the previous equilibrium condition. Thus, static equilibrium concepts should be replaced by dynamic ones, that is, steady-state positions (see Juselius, 1999). Good approximations of rigid static equations are cointegrating relations. In the analysed case the corresponding cointegrating relation is of the form:

$$m_t - p_t - L(y_t, r_t) = \upsilon_t \tag{2a}$$

where υ_t is a stationary variable measuring the deviation from the equilibrium.

[1] all variables, except for the interest rate, are in logs

Wages inflation

The key factor of wage inflation is excessive wages growth not covered by the productivity growth. Writing a real wage equation as a function of productivity and unemployment yields:

$$w - p = f(z,u) \tag{3}$$

with z for productivity, and u denoting unemployment.

Increases in real wages outweighing increases in the productivity create inflationary pressure. In terms of a cointegrating relation one could write:

$$w_t - p_t - f(z_t,u_t) = v_t \tag{3a}$$

Imported inflation

The imported inflation results from the lack of adjustment of domestic and foreign prices and the relevant nominal exchange rate. A benchmark for ascertaining the impact of foreign prices on the domestic price level can be provided by purchasing power parity theories. Defining the PPP equation as:

$$p = e + p^f \tag{4}$$

where

e - nominal exchange rate in domestic currency per foreign currency,

p^f - foreign prices,

one obtains a cointegrating relation of the form:

$$p_t - e_t - p^f_{ft} = \xi_t \tag{4a}$$

4. INFLATION PROCESSES IN GERMANY

The analysis of the inflation in Germany is based on quarterly data encompassing period from 1980.1 to 2001.4 [2]. All variables used are I(1). Deterministic factors are seasonal

[2] Sources for the data are DIW and Deutsche Bundesbank. All variables, except for the short-term interest rate, are in logs. Values of the German money stock (m) after the euro introduction were constructed as a percentage share in the money stock of the European Monetary Union countries. The percentage share amounted to 18.5%, which value was obtained as an average share of the German money stock in the euro money stock in the period 1997.4 - 1998.4.

variables and dummies for the structural break resulting from the German unification[3]. The constructed empirical model diverges slightly from the model outlined above. The main difference results from specific properties of the German data that not always permit an explicit estimation of the theoretical relations. The initial form of the model encompasses only two cointegrating relations – one for the money market and one for the labour and exchange rate market jointly. The second relation of hybrid character was derived as there were no plausible functions found that would reasonably reflect the labour market situation. Hence, the mark up model was implemented that enabled modelling price increases as being driven by unit labour costs (proxy for labour market situation) on the one hand, and import prices on the other hand.

Monetary factors - disequilibrium on the money market

Estimation of the standard money market equilibrium equation, where the real money stock equals the money demand being a function of the real GDP level and the short term interest rate did not provide satisfactory results.[4] To get plausible coefficients' signs the German Bond Index (*Deutscher Rentenindex* – REX) was used instead of the interest rate as an opportunity cost measure. As a result the following regression was obtained[5]:

$$m - p = seasonals + \underset{(20,82)}{1.89}\, y - \underset{(2,83)}{0.26}\, rex \qquad (5)$$

R-squared=0.98 DW=0.51

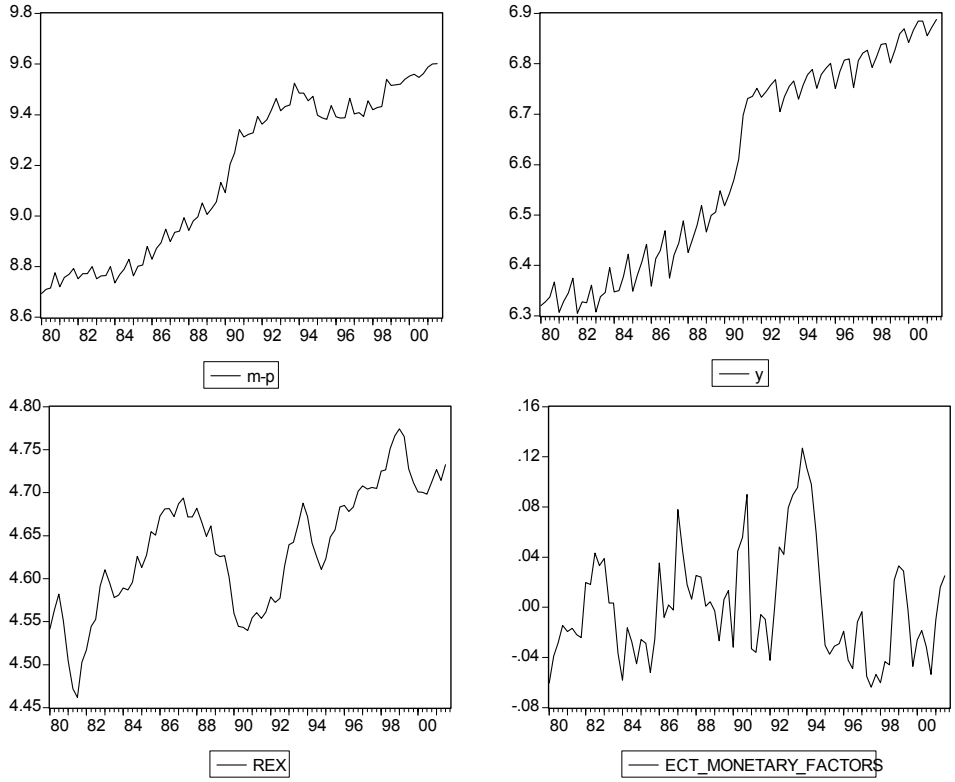
Long-run elasticities of money demand in regard to the GDP and opportunity cost amount to 1.89 and 0.26 respectively. Statistic properties of the model fulfil the required criteria and the residuals obtained are stationary[6]. The deviation of the real money stock from the GDP level and the interest rate level reflects the scale of the disequilibrium on the money market which could create the inflationary pressure. Figure 1 pictures variables of interest and the corresponding error correction term.

[3] The structural break for German unification affected also the seasonality pattern of German prices. Thus, when reporting the results later in the text deterministic dummies are not explicitly mentioned as they are encompassed by the seasonals.

[4] It was also tested whether the quantity theory holds. The equation $m - p = y - v$ with v denoting the log velocity of money did not prove to be supported by the data. There was no cointegrating relationship found between the real GDP, the consumer price level and the nominal money stock (neither M1 nor M2 nor M3).

[5] The money stock m corresponds to the M2 aggregate.

Figure 1. Real money, real GDP, short term interest rate and the corresponding cointegrating vector.



Production factors - disequilibrium on the market of production factors

Since no plausible cointegrating relation between prices, wages and productivity was found, the condition on the wage inflation sources was rearranged into the cost push inflation condition. The structure of the model used, responded to the mark up model. Prices were defined as a mark up over unit labour costs and import prices. Introduction of import prices into the equation eliminated the necessity of adding an additional cointegrating relation that would reflect the influence of world prices and exchange rates shocks.

Thus, the function was defined as:

$$p = f(ulc, p^{imp}) \tag{6}$$

where:

ulc - unit labour costs

p^{imp} - import prices

and estimation of the parameters yielded:

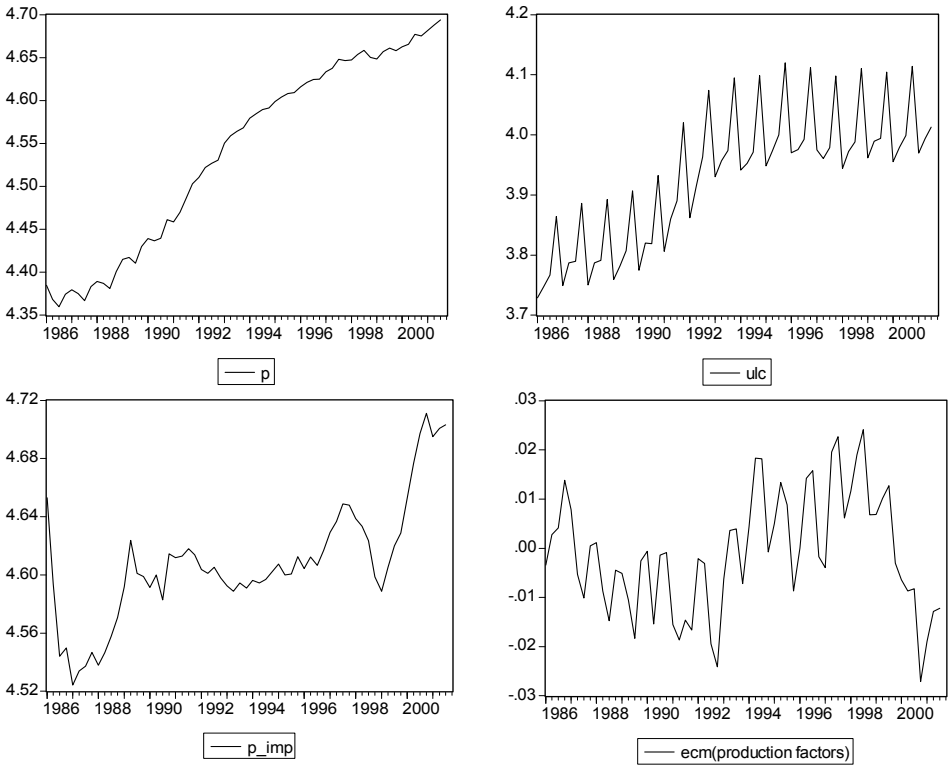
$$p_t = seasonals + \underset{(13.77)}{0.003}\,t + \underset{(10.83)}{0.3}\; p_t^{imp} + \underset{(13.08)}{0.52}\,ulc \tag{6a}$$

R-squared=0.99 DW=0.81

[6] ADF test

Long-run impact of import prices accounts for 0.3 and unit labour costs enter the equation with coefficient 0.52. The condition on residuals to be stationary was obtained only when a linear trend was added. Economic explanation for the linear trend in the equation for the long run could be searched for in agents' expectations. As the monetary policy of the ECB (and also earlier (at least implicitly) of the Bundesbank, see Bernanke, Mishkin, 1996) was oriented at an inflation target, and not an price-level target, which implies permanent growth of prices, market agents, and among them producers, expected automatically that the prices would grow. Figure 2 plots the variables of interest, that is, prices, unit labour costs, import prices and the corresponding cointegrating vector.

Figure 2. Prices, unit labour costs, import prices and the corresponding cointegrating vector.



Demand factors

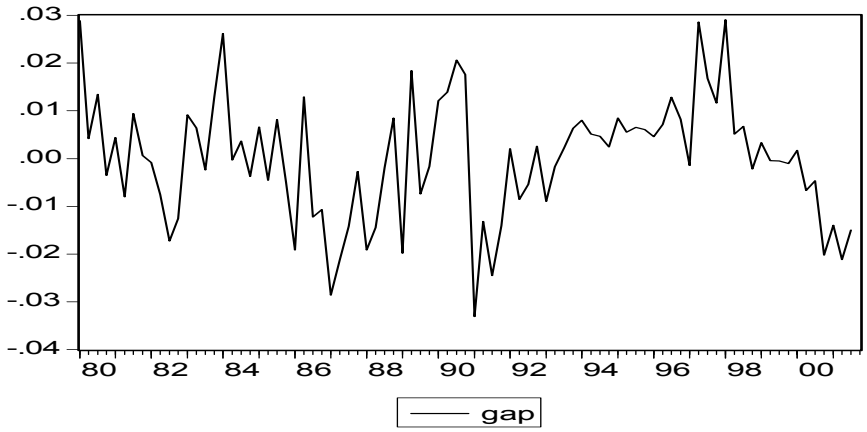
The inflation equation includes also a proxy for the production activity. The variable used was constructed artificially, as there is no commonly accepted output gap definition. The deviation of output from the linear trend which appears in many studies as an output gap measure, does not seem to be a plausible one. Stochastic properties of the GDP times series, being integrated of order one, automatically imply that subtracting a deterministic trend will not produce a stationary zero-mean process - the deviation between the stochastic and deterministic trend is not stationary.

To obtain an econometrically feasible measure of the capacity utilisation the model applied an output gap concept developed by Mizon and Marcellino (2000), who define this variable as a trend adjusted productivity[7]. Using the data for Germany, the following regression was obtained:

$$gap_t = (y - l)_t - \underset{(47.13)}{0.006}\, t + seasonals$$

with l denoting the level of employment measured with hours paid. According to the ADF test the *gap* proved to be stationary at the significance level of 1%. The constructed variable could be interpreted as a deviation of the log productivity from its long run path (proxied by a trend) reflecting the level of the technological progress and developments on the labour market. Figure 3 plots the constructed variable.

Figure 3. Output gap.



Other factors

To capture for the short run dynamics of inflation behaviour the model included also lagged values (8 lags) of the inflation rate, the money stock (first differences), the interest rate (first differences), unit labour costs (first differences) and import prices (first differences). Centred seasonal dummies and dummies for the lagged effects of the structural break were also added. Hence, the initial model was:

[7] The inflation model used also three modified versions of the 4-th difference filter. All modifications made, enabled deletion of the outlier resulting from the German unification and shifting the mean value to 0%, which should better correspond to the traditional concept of the pressure on productive capacity. However, none of the variables constructed proved to be significant when modelling inflation behaviour.

$$\Delta p_t = deterministic\_variables + \alpha ect(production\_factors) + \beta ect(monetary\_factors)$$
$$+ \gamma_0 gap_t + ... + \gamma_8 gap_{t-8} + \delta_1 \Delta p_{t-1} + ... + \delta_8 \Delta p_{t-8} + \varphi_0 p_t^{imp} + ... + \varphi_8 p_{t-8}^{imp} + \tau_0 \Delta ulc_t + ... + \tau_8 \Delta ulc_{t-8}$$
$$+ \phi_0 \Delta m_t + ... + \phi_8 \Delta m_{t-8} + \lambda_0 \Delta r_t^s + ... + \lambda_8 \Delta r_{t-8}^s \tag{8}$$

Using the modelling strategy *from-general-to-specific* and dropping insignificant variables, the following final inflation model was obtained (t statistics in parentheses):

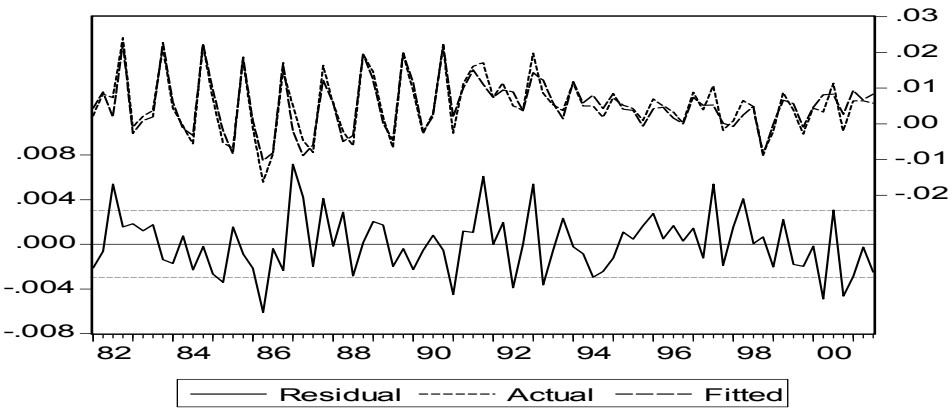
$$\Delta p_t = deterministic\_variables - \underset{(6.23)}{0.26}\, ect(production\_factors) + \underset{2.61}{0.09}\, gap_{t-1}$$
$$- \underset{(3.33)}{0.27}\, \Delta p_{t-2} + \underset{(6.41)}{0.39}\, \Delta p_{t-4} + \underset{(4.9)}{0.32}\, \Delta p_{t-6} + \underset{(5.62)}{0.12}\, \Delta p_t^{imp} + \underset{(4.34)}{0.09}\, \Delta m_{t-4} - \underset{(3.71)}{0.002}\, \Delta r_{t-7}^s \tag{9}$$

Table 1 contains statistical properties and diagnostic tests for the model and figure 4 shows the inflation model fit and the residuals.

Table 1. Statistical properties of the model (p values in brackets).

Statistic	
R-squared (adjusted)	0.86
D-W statistic	2.03
Normality-Test (J-B)	1.69 (0.43)
Serial correlation LM-Test (1 lag)	0.07 (0.8)
Serial correlation LM-Test (4 lags)	0.45 (0.77)
ARCH LM-Test (1 lag)	0.24 (0.62)
ARCH LM-Test (4 lags)	2.7 (0.04)
Parameter constancy – CUSUM-Test	Within the band
Parameter constancy – CUSUM2-Test	Within the band

Figure 4. Actual and fitted values, and residuals.



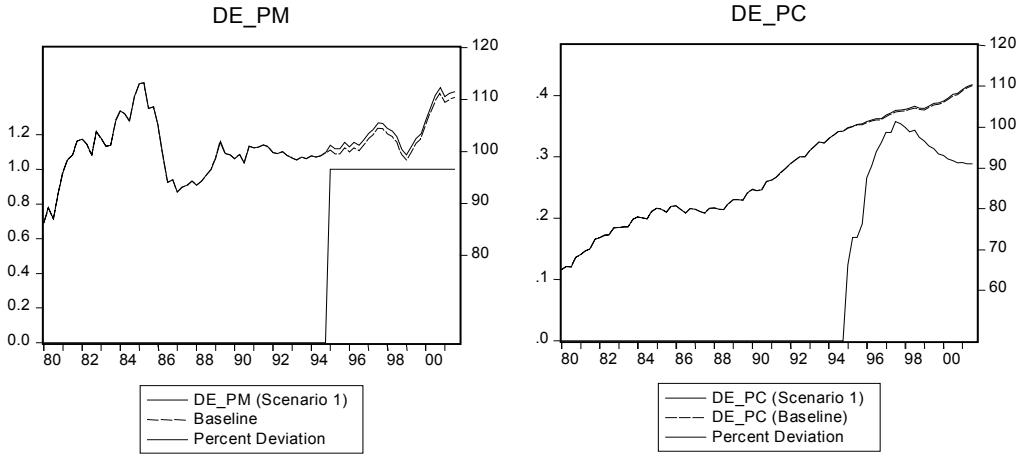
5. MODEL INTERPRETATION

The approach of using cointegration to describe equilibria with the deviations representing disequilibria sources causing inflation enables good description of the data.

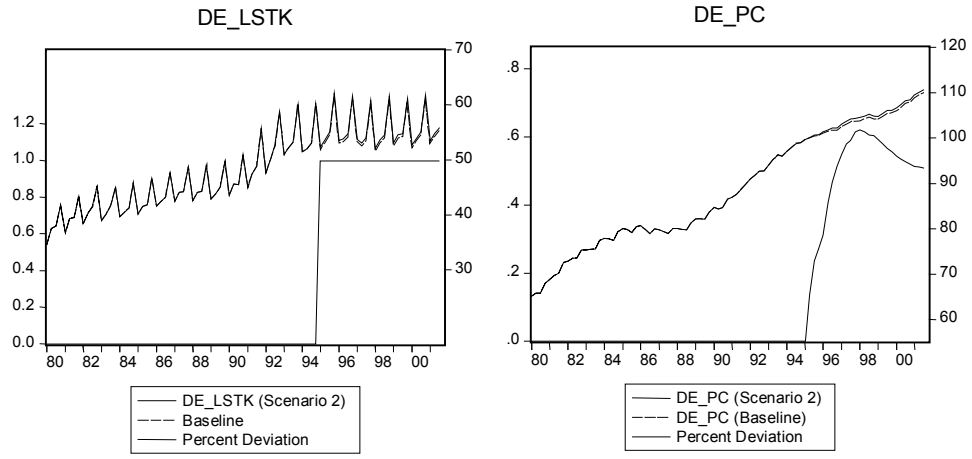
As it can be seen from the equation (9), excess money does not have a significant impact on the inflation – disequilibrium on the money market and adjustment processes between the real money stock, real GDP and interest rates do not lead to excessive growth of prices. However, disequilibrium on the market of production factors has a significant, 0.26 effect on inflation. The output gap has a lagged, positive impact of 0.09. Monetary policy variables proved to be significant when explaining inflation behaviour. Money growth has an influence of 0.09 and an interest rate increase by 1% results in inflation fall by 0.2 basis points. Inflation responds to policy actions only with lags – 4 and 7 quarters in case of the money growth and interest rate changes respectively. International factors embodied in import prices enter the inflation equation two times – once via the cointegrating relation and the second time directly with a 0.12 effect. Lagged values of the inflation rate also contribute to inflation movements. Inclusion of centred seasonal dummies into the equation does not permit interpretation of the constant and drawing inference about a possible exogenous inflation growth.

To illustrate the functioning of the model the pictures below show simulations of the reaction of the price level to changes in independent variables – a 1% -change in import prices (simulation 1), 1% change in unite labour costs (simulation 2) and 1%p.a. change in the interest rate (simulation 3).

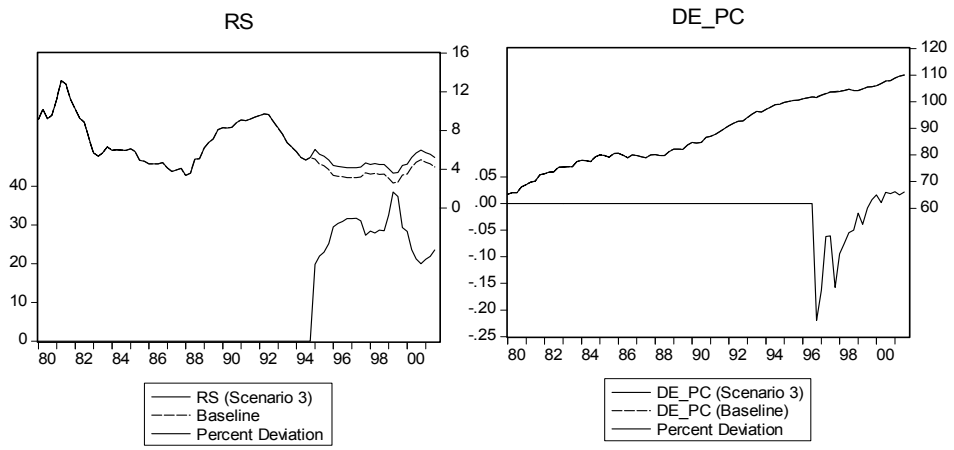
Simulation 1. Effect of a 1% permanent increase in import prices.



Simulation2. Effect of a 1% permanent increase in unit labour costs.



Simulation 3. Effect of 1%p.a. permanent increase in interest rates.



The simulation results suggest that a 1% permanent increase in import prices leads to a permanent increase in the price level with the long run elasticity of 0.3. Prices grow by 0.52% in the long run in response to a 1% permanent shock coming from import prices. A hike in interests rates (a permanent change - 1% p.a.) will result in a decrease in the dependent variable by 0.2 basis points which effect decays with time.

6. CONCLUSION

In the paper an equlibrium correction model of the German inflation was estimated. The eclectic approach applied, enabled examination which potential inflation sources matter empirically. According to the obtained results, inflation in Germany results from adjustment processes on the market of production factors, level of capacity utilisation, external shocks embodied in import prices and monetary policy actions. Excess money being an effect of

disequilibrium on the money market does not matter empirically when studying inflation behaviour.

The study provides several implications for macroeconomic policy. It reveals that wage policy is an important factor affecting price movements in the long run. Unit labour costs being significant in the inflation equation indicate that labour unions and government authorities while determining wage contracts and devising employment policy should be aware of price effects of their policies so that a threat of price-wages spiral is minimised. The fact that developments on the labour market are crucial for price movements is supported by significance of the productivity based output gap in the equation.[8]

Both money supply and interest rates turned out to have a significant influence on inflation in Germany. Such a result is a consequence of the character of the monetary policy conducted in Germany in the last twenty years. Although the Bundesbank officially targeted money supply growth, it is often claimed that it was an implicit inflation targeter. Interest rates were also an instrument used when controlling inflation. Strategy of the ECB which is responsible for the monetary policy in the euro area, and thus in Germany since 1999, consists of two pillars which correspond to money growth and inflation targets.

The eclectic approach employed here is very informative and could be applied for studying inflation in other countries. Analysis of forces driving inflation in member countries of the euro area could be an interesting aspect of further research that would bring insights which policies matter while controlling inflation. Such information would be essential when devising a common policy – e.g. monetary (or possibly fiscal (in this case it would be interesting to investigate whether fiscal imbalances contribute to inflation movements)) – as it could help determine country weights taken into consideration while developing the single policy, and national policies – e.g. labour or fiscal – as it would indicate which instruments should be used.

Eclectic modelling could also be applied for studying other macrovariables – exchange rates, consumption, exports etc. Cointegrating relations would correspond to different macroeconomic policies (monetary and fiscal policies) or economic theories (e.g. theories based on macro and microfundamentals).

[8] Output gap based on the trend adjusted productivity turned out to be the only significant output gap measure.

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